# European Oaks—Susceptible to Oak Wilt?

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Oak wilt, caused by the fungus *Ceratocystis fagacearum* (T. W. Bretz) J. Hunt, occurs only in the midwestern and eastern United States. The spread of this disease among native oak species in most areas is slow and sporadic. The disease, however, can be very significant to property owners who have experienced the aesthetic and economic impact that results from the loss of ornamental and forest-grown oaks (3). The original purpose of this research was to determine the susceptibility of European oaks to oak wilt and, hence, estimate the threat of the pathogen to oak forests in Europe in the event the causal fungus is introduced to that continent. The study also provides useful information to arborists about the relative susceptibility of European oak species to oak wilt when used in landscape plantings in the United States. Prior to this experiment, only one study examined the behavior of European oaks when inoculated with *C. fagacearum* (1). In the earlier test, 1 to 2-year-old seedlings were inoculated and became symptomatic after 3 to 5 weeks. Unfortunately, neither the extent of subsequent disease development nor the response of older trees to infection was examined. The need to test larger European oak species for their susceptibility to oak wilt has been a recurring issue.

In North America, European oaks are widely available in the nursery trade and some species have been planted extensively (Table 13.1). *Quercus robur*, English oak, is best known as a large, reasonably fast growing, sturdy white oak that adapts well to various soils and climates. Its deep green foliage is outstanding. A variety of cultivars are available, and the fastigiate form of the species has been popular in landscapes where a columnar shape is desired (Table 13.1). Other European species are planted less commonly but can be found in arboreta.

## EXPERIMENTAL PROCEDURES

Although sources of European oaks exist in North America, this experiment utilized acorns that were imported directly from sites throughout Europe. In this way, the susceptibility of most major European species from a variety of locations could be evaluated. Because the screening was to be done with large trees, the study required that acorns be imported, germinated, and grown for 12 to 15 years before they could be inoculated with *C.*

*fagacearum*. Test arboreta were established on university experiment station properties at Clemson, SC and Morgantown, WV, where they could be established and maintained with the least expense and were under some degree of control. Acorns were collected in Europe by colleagues or their associates. Seed representing 22 different European sites were supplied for planting in South Carolina or West Virginia (Table 13.2).

Shipments of acorns from France to the United States were made between 1982 and 1984. Prior to their shipment, acorns were treated with heat and Thiram to reduce the risk of introducing insects or pathogens. All shipments were made under the authority of the U.S. Department of Agriculture, Animal and Plant Health Inspection Service. The acorns were stratified, planted in nursery beds, and held there through one or two growing seasons before outplanting to the arboreta. Several problems were encountered in the nursery and with establishment of the arboreta. Viability of acorns of some seed sources was very low. For others, germination rates were adequate, but

TABLE 13.1. Major European oaks (*Quercus* sp.) in the North American nursery trade

| Common name | *Quercus* species | Cultivar |
|---|---|---|
| English oak | *Q. robur* (=*Q. pedunculata*) | Skymaster |
| | *Q. robur 'Fastigiata'* | Rosehill |
| | | Pyramid |
| Sessile oak | *Q. petræa* (=*Q. sessiliflora*) | |

TABLE 13.2. Location, species and country of origin of oaks included in test arboreta

| Location | *Quercus* species | Country of origin |
|---|---|---|
| Clemson, SC | European species | |
| | *Q. robur* | Germany, France, England, Scotland |
| | *Q. petræa* | Germany, France, Italy, Ireland |
| | *Q. pubescens*[a] | Italy |
| | Susceptible controls | |
| | *Q. rubra* | United States |
| | *Q. falcata* | United States |
| | *Q. nigra* | United States |
| | Resistant controls | |
| | *Q. alba* | United States |
| | *Q. virginiana* | United States |
| | *Q. stellata* | United States |
| Morgantown, WV | European species | |
| | *Q. robur* | Germany, Italy, France, Netherlands |
| | *Q. petræa* | France, Scotland, Ireland |
| | Susceptible control | |
| | *Q. rubra* | United States |
| | Resistant controls | |
| | *Q. alba* | United States |
| | *Q. prinus* | United States |

[a] Replicate numbers of this oak species were not sufficient to warrant analysis.

survival of seedlings in the nursery was poor. Conversely, some seed sources of *Q. robur* and *Q. petræa* grew quite well, in some cases even better than the native white and red oaks planted as controls. This behavior has been noted by others (2). Predation by squirrels was a problem in nursery beds even though trees were covered with hardware cloth. In West Virginia, browsing by deer necessitated that the arboretum be enclosed with an electrified fence. In South Carolina, the decade of the 1980s was much hotter and drier than usual and drought-related losses after outplanting were probably much greater than they might have been if weather conditions had been normal.

During the intervening years, while the arboreta were being maintained, a variety of tests were conducted using extra seedlings (4). These tests were designed to insure that the outcome of the final susceptibility screening would be as accurate and useful as possible. Specific issues that were addressed included (i) sources of *C. fagacearum* isolates to be used as inoculum; (ii) time of inoculation for optimum symptom development; (iii) sites on the tree where inoculation would be made; and (iv) development of a rating system that would effectively measure differences in susceptibility.

In the spring of 1996, 12 to 14 years after the importation of the acorns from Europe, the trees were inoculated on 29 April and 5 and 6 June at Clemson and Morgantown, respectively. These dates fell during periods that had been determined from prior inoculation studies to be optimal for symptom development. Two virulent isolates of *C. fagacearum* from Wisconsin and a third one from West Virginia were used for inoculum. The spore mixtures of the three isolates contained from $10^6$ to $10^7$ asexual spores of the fungus per ml in a 0.1% sterile peptone solution. Small wounds were made to introduce the inoculum to either the main stems or branches using a small chisel or dissecting needle. A droplet of inoculum was placed at the site of inoculation prior to wounding. In both arboreta, susceptible red and resistant white oaks from North America were included as standards for comparing disease development (Table 13.2). Symptom expression was evaluated by a rating team that examined and scored each tree for the portion of the crown that expressed wilt or dieback symptoms. The first ratings were conducted at Clemson on 27 May 1996. Subsequent ratings were made on 3 June and 25 July in 1996 and on 2 May and 9 July in 1997. A final evaluation was made at Clemson on 1 May 1998. In Morgantown, evaluations were made on 25 June, 9 and 22 July, 7 August, and 18 September in 1996. Additional readings were made on 11 June, 7 and 24 July, 6 September, 1997 and 22 July 1998. All data were analyzed statistically using a general linear model procedure that compared the rates of disease development among the species. In addition, an effort was made in Morgantown to establish root graft transmission relationships from trees that were inoculated to those that were not.

## RESULTS

Wilt symptoms were evident in most inoculated trees within 1 month of inoculation at both the Clemson and Morgantown arboreta, regardless of whether inoculations were made to the branches or the main stem (Figs. 13.1 to 13.4). The type of disease symptoms expressed by the European white oaks generally was similar to that of the North American species and included water-soaking and necrosis of foliage, and leaf abscission. At both locations, the main stem inoculations produced higher wilt and dieback ratings at the earlier assessment dates than branch inoculated trees, but, these differences were not statistically significant. By the end of the 1996 season, the level of symptom development was similar whether the inoculations were made to the main stems or branches.

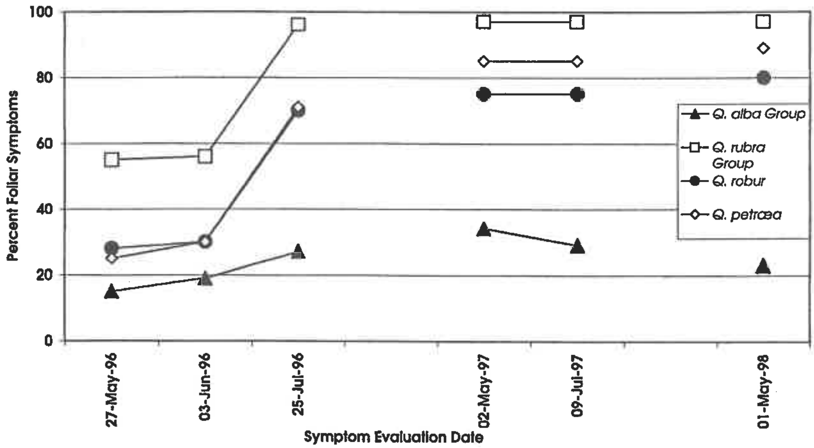


**Fig. 13.1.** Oak wilt symptom development for European and North American oaks averaged for each *Quercus* spp. when main stem inoculated with *Ceratocystis fagacearum* in the spring of 1996 at Clemson, SC.

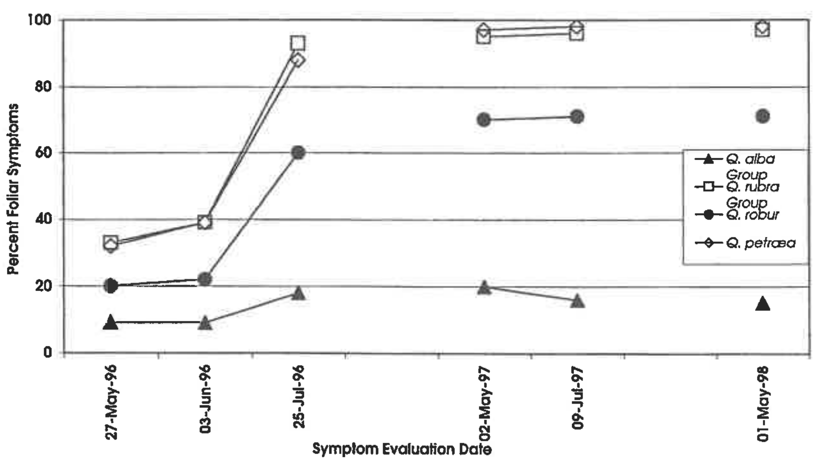


**Fig. 13.2.** Oak wilt symptom development for European and North American oaks averaged for each *Quercus* spp. when branch inoculated with *Ceratocystis fagacearum* in the spring of 1996 at Clemson, SC.

At the Clemson, SC arboreta, the North American red and white oaks included as standards yielded the type and level of symptoms anticipated; the susceptible red oaks expressed almost 100% crown involvement and the resistant white oaks displayed only about 20% symptom expression at the end of the first season (Figs. 13.1 and 13.2). The course of disease development did not change appreciably during the following 2 years for the resistant white oaks. Symptom development in *Q. petræa*, the European sessile oak, paralleled that of the susceptible American red oaks, approaching 100% wilt and dieback by the end of the first season. No evidence of recov-

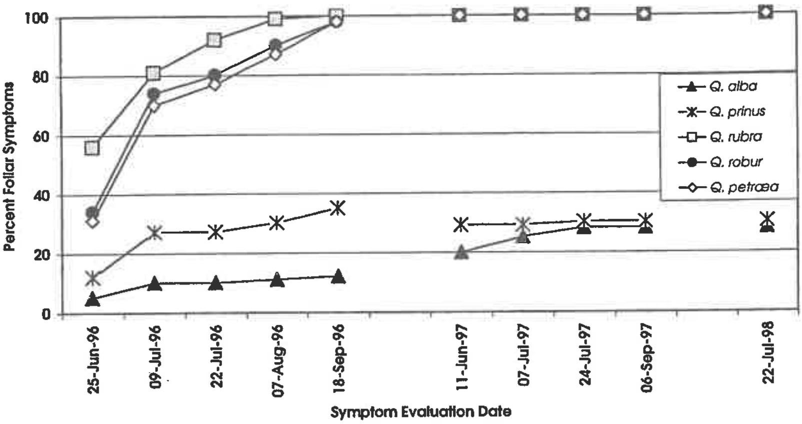


**Fig. 13.3.** Oak wilt symptom development for European and North American oaks averaged for each *Quercus* spp. when main stem inoculated with *Ceratocystis fagacearum* in the spring of 1996 at Morgantown, WV.

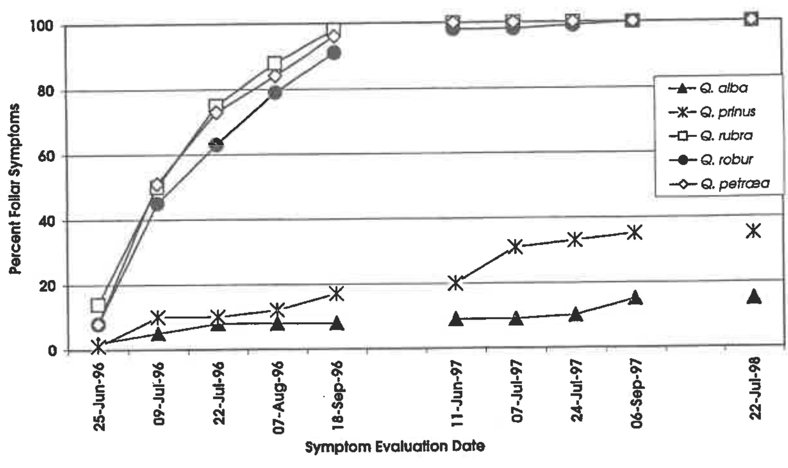


**Fig. 13.4.** Oak wilt symptom development for European and North American oaks averaged for each *Quercus* spp. when branch inoculated with *Ceratocystis fagacearum* in the spring of 1996 at Morgantown, WV.

ery from wilt existed in 1997 and, by 1998, most of these trees were dead. In 1996, *Q. robur*, English oak, developed about 70% crown symptoms whether the branch or main stem was inoculated. Those ratings were sustained through the 1997 and May 1998 evaluations. Although data for *Q. pubescens* are not presented, this species also was highly susceptible, expressing 100% symptoms whether the branch or stem was inoculated.

At the Morgantown, WV arboreta, symptom progress in the two European white oak species, *Q. robur* and *Q. petræa*, was similar to *Q. rubra*, the susceptible North America red oak standard (Figs. 13.3 and 13.4). By the end of the 1996 season, most trees representing these three species were dead or dying. In contrast, *Q. alba* and *Q. prinus*, the two 'resistant' North American white oaks, produced symptoms by the end of 1996 growing season that ranged from 10 to 30%, respectively. In subsequent years, wilt and dieback ratings for these two species did not change appreciably.

## CONCLUSIONS

The most significant finding from this research is that symptom development among the European white oak species is rapid, complete, and very similar to the high degree of susceptibility expressed by North American red oaks. In fact, most of the European white oaks were dead or dying by the end of 1996, the year of their inoculation. This outcome was not anticipated given the fairly high level of resistance that most North American white oak species express. The reduced level of disease in the European sessile oak, *Q. petræa*, at the Clemson arboretum is unexplained, but this finding is consistent with other preliminary inoculation tests conducted at that site. Because this species expressed high levels of susceptibility and died when tested in Morgantown, its response to disease in Clemson may relate more to the climatic or site conditions that exist there. Although this situation may warrant further scientific evaluation, the limited tolerance to *C. fagacearum* expressed by *Q. petræa* does not appear to be adequate to allow for the long-term growth and survival of this species when infected. The critically important message for arborists in the United States is that European oaks are highly susceptible to oak wilt and their use and care in landscape settings should be considered cautiously, especially in areas of high oak wilt incidence.

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